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EVALUATION OF OAK WILT ON NECEDAH NATIONAL WILDLIFE REFUGE, WISCONSIN

by

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INTRODUCTION

Oak wilt, caused by the fungus Ceratocystis fagacearum (Bretz) Hunt, is a primary cause of oak mortality on Necedah National Wildlife Refuge in south-central Wisconsin (Figure 1). The oak type, made up of 95 percent red oak, occupies 7,800 acres of Refuge land and comprises a volume of about 54,000 cords. Refuge administrators have recognized the serious effects this disease can have on their woodland resources and associated wildlife species. Squirrels, white-tailed deer, and other species of wildlife use acorns as a primary food source.

At the request of Refuge administrators, personnel from the Forest Service, Forest Insect and Disease Management Staff Unit, evaluated the oak wilt problem on Necedah Wildlife Refuge. This report summarizes results of the evaluation and provides treatment recommendations.

Oak wilt has been present in Wisconsin for more than 35 years. The oak wilt fungus first was described and identified in Wisconsin in 1942 (True and Gillespie 1961). Since that time, oak wilt has spread primarily eastward and southward. The disease is now found in at least 21 states and more than 600 counties (Jones and Phelps 1972, Rexrode and Lincoln 1965). In 1977 (Worf and Kuntz 1978), oak wilt was reported in 46 Wisconsin counties (Figure 2).

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All species of oak on Necedah Refuge are susceptible to oak wilt. The red oak group is most susceptible, white oak the least, and bur oak intermediate. Infected red oak trees die within 3 to 8 weeks after symptoms appear; white oak and bur oak may last for several years and will sometimes recover (French and Stienstra 1973). Disease symptoms vary with the tree species. Red oak leaves die from the leaf margin inward, while white and bur oak leaves die from tip to base.

A second symptom of oak wilt is discoloration of the outer sapwood from invasion of water-conducting vessels by the fungus. The tree responds to this invasion by increasing production of gums and tyloses which clog the vessels. Spore mats may be produced under the bark of infected trees. These mats are usually about 1 inch wide and 4 to 8 inches long.

The oak wilt fungus is spread in two ways. Local spread (i.e. within 50 feet of an infected tree) is primarily by transmission of the fungus through root grafts between infected and healthy trees. Root grafting is most common in light soils of the Lake States but also occurs in other geographical areas (Rexrode and Frame 1977). Sap-feeding insects of the family Nitidulidae are the primary vectors in long-distance spread of oak wilt. Insects are attracted to fungal mats by an odor of fermentation. Spores adhere to the insect and can be transported to nearby trees. This type of spread is most effective when healthy trees are wounded. Wounds provide entry points for the wilt fungus and attract sap-feeding insects.

A 1954 survey of eight counties in central Wisconsin revealed that about 2 percent of the oak type was infected with oak wilt and 0.3 percent of the volume was killed annually. Although this volume loss appears relatively low, approximately 11 percent of the annual growth increment in oak forests was offset by mortality from the disease (Anderson and Skilling 1955). In some areas of Wisconsin, mortality rates have exceeded 50 percent and highly susceptible species of oak are threatened with elimination.

OBJECTIVES

Objectives of the evaluation were to locate oak wilt infection centers, quantify current timber volume losses, and assist the Refuge forester in managing the disease problem.

METHODS

Aerial survey.

Aerial photographs of the Necedah Wildlife Refuge were taken August 7, 1978, with a 9x9 inch format Zeiss camera. An 8.25-inch focal length, 1:8000 scale, and Ektachrome Infrared Aero film (type 2443) were used. Photography was done by Western Mapping Co., Inc. of Portland, Oregon. Photo interpretation was done at the Forest Insect and Disease Management laboratory in St. Paul, Minnesota.

Photo interpretation. (Part I).

Old Delft stereoscopes set at 4.5 power over a light table were used in the interpretation. Initial interpretation involved marking all potential oak wilt infection centers on overlays and recording them as clusters or single trees. A cluster consisted of three or more trees. During photo interpretation, three characteristics of disease occurrence were used to identify potential infection centers:

1. Dead trees - bare branches appearing dark and blue-gray with skeletonlike shadows visible in open areas.

2. Wilted trees - dark yellow color in all or part of the crown.

3. Infection center - a ringlike pattern with dead trees in the center and wilting trees along the edge.

Ground truth.

Accessible single trees and clusters suspected of having oak wilt were ground-checked in October. A cluster was considered infected if one or more trees had oak wilt. Tree species and condition class were recorded for sample trees or clusters. Condition classes were:

1. wilted; oak wilt-infected
2. dead; oak wilt-infected
3. dead; other disease or insect

Criteria used to determine presence of oak wilt were: 1) presence of a fungal (mycelial) mat between bark and wood, 2) discoloration in outer sapwood and/or a fermenting odor, 3) leaf symptoms such as wilt, premature drop, and browning of leaf margin, and 4) a ringlike pattern of the infection center. When presence of infection was uncertain, branch samples were collected for laboratory diagnosis. Timber volume (cords per tree) was estimated for one tree at each ground-check location where oaks were found.

Photo interpretation (Part II).

Following the ground-check, a second photo interpretation was made to include final corrections. The trees in each cluster that displayed oak wilt were counted and recorded. All oak wilt infection centers were plotted on a Refuge map and photo mosaic.

Data analysis.

The total number of infected trees was determined from photos, a ground-check of suspected infection centers, and application of a ground-check correction factor to the initial photo counts. The ground-check correction factor was the ratio of confirmed oak wilt centers to the total number of suspect oak wilt centers ground-checked. The correction factor was used to estimate the total number of infected trees by condition class. An overall timber volume estimate was derived by averaging cords per tree sampled at ground-check locations.

RESULTS

Ninety-eight clusters and 160 single trees with oak wilt symptoms were identified on the aerial photos. Forty of the clusters and 17 single trees were ground-checked. Seventy-five percent ($\pm$12.5%, α = .10) of the clusters had one or more trees infected with oak wilt. Five (29 $\pm$21%, α = .10) of the single trees were infected. In six trees, the presence of oak wilt was uncertain and branch samples were taken. Laboratory diagnosis indicated that three of these six trees were infected. All trees examined were in the red oak group.

On the basis of photo interpretation, 4,363 oak trees were classified as dead or wilting. Of these, 2,604 were considered infected by the oak wilt fungus. Table 1 shows the number, average volume, and condition class of infected trees. Estimates are provided with and without a ground-check correction factor.

Timber volume measurements were taken at 44 of 57 ground-check locations. Because the other 13 locations contained tree species other than oak, volume measurements were not taken. Average volume for dead and wilting trees infected with oak wilt was 0.179 cord per tree (SE = 0.023).

Various other diseases and insects were encountered during the ground-check survey. The most frequently encountered diseases were Armillaria root rot, Armillaria mellea (Vahl ex Fr.) Kummer, flooding, and wind breakage. The most common insect found was the two-lined chestnut borer, Agrilus bilineatus (Web.). Several mortality centers were caused by ground fires.

DISCUSSION

Although many mortality agents were detected during the survey, the primary cause of tree mortality was the oak wilt fungus. The disease was responsible for the death of about half the dead trees detected. Current tree mortality from oak wilt is less than 1 percent of the total volume of oak on Necedah Wildlife Refuge. This volume loss is similar to that found in a survey of central Wisconsin counties, where 0.3 percent of the total volume was killed annually by oak wilt (Anderson and Skilling 1955).

Loss of timber volume on Necedah Refuge is of secondary importance, since the primary objective of Refuge timber management is to enhance wildlife habitat. Current losses of large oak trees may significantly reduce the mast crop and alter wildlife habitat. Oak wilt may be of particular importance on Necedah because of the large proportion of red oak (95 percent). The red oak group is highly susceptible to oak wilt and the mortality rate for infected trees is 100 percent (Himelick and Fox 1961).

Oak wilt will continue to spread from many infection centers, essentially eliminating red oaks in some areas. In areas where red oak is eliminated, oak wilt will probably die out from lack of suitable hosts. The length of time infection centers are active depends on the size of the center. Himelick and Fox (1961) found that 1 percent of the infection centers with less than five trees were active after 5 years, while 82 percent of the centers with more than five trees still were active after 5 years. Data regarding rate and direction of spread were not collected in this survey. Spread rates in the Lake States range from 3 to 5 feet per year (Anderson and Anderson 1959) to 25 feet per year (French and Bergdahl 1973). Many factors affect the rate of spread, but shallow soils, availability of compatible oaks, and the number of dead and currently wilting trees at an infection center were primary factors in a northeastern West Virginia study (Gillespie and True 1959). Because most spread occurs by root contact between diseased and healthy trees, contiguous stands of red oak have the greatest potential for loss. Park-like open stands will have less tree mortality and may be barriers to disease spread. Spread by insect vectors will be most effective in wounded trees.

Aerial photography was useful for detecting tree mortality, but comparison of photo counts and ground-check data show a 25 percent overestimate for clusters of trees infected with oak wilt. The error was 71 percent for single infected trees. The primary errors were detecting mortality of tree species other than oak and identifying mortality caused by other diseases or insects. Many single dead trees were located along canals or in flooded areas; they often had soil washed away from the roots or roots suffocated by standing water. A major problem in identifying single infected trees was deterioration; trees were infested with secondary diseases or insects, making detection of oak wilt difficult. Identification of oak wilt-infected trees in clusters was much easier because the trees were in all stages of decline. Deteriorating dead trees, recently killed trees, and wilted trees often were present in each cluster.

CONCLUSIONS

The following conclusions are based on the aerial and ground survey for oak wilt on Necedah Wildlife Refuge:

1. A total of 4,363 red oak trees were dead or dying.

2. Oak wilt was the primary mortality factor (43 percent) in red oaks, with at least 1,879 infected dead or dying trees on the Refuge.

3. Aerial photography was effective for locating dead trees, but the commission error was very high for single infected trees.

4. Current timber volume loss from oak wilt is not significant.

5. Wildlife habitat will be altered in infection centers

ALTERNATIVES

Factors to consider in choosing a control alternative include biological soundness, economic efficiency, and effectiveness. Each of these factors has an integral role in any control decision making process. Although numerous methods are available for minimizing the impact of oak wilt, there are only three basic alternatives for control. Biological aspects of these three alternatives will be discussed, followed by a comparison of cost and effectiveness for current control procedures.

Alternative 1.

This alternative is to make no effort to suppress oak wilt, allowing the disease to spread unchecked until it dies out naturally. With this alternative, the rate of oak mortality will increase as infection centers expand. In open stands, oak wilt will spread slowly. Rate of spread will increase as tree density increases. Information regarding rate of spread on Necedah Refuge was not collected in this evaluation, so the rate of stand deterioration cannot be predicted at this time. Infection centers will die out as host material is eliminated or when tree density decreases enough to preclude root grafting. Red oak will be essentially eliminated from active infection centers. Openings of various sizes will be created in the oak type. Mast production will decrease in proportion to the increase in infection center size. Timber volume loss will be insignificant in the next 5 years, but may become important thereafter.

Alternative 2.

A large-scale oak wilt control program designed to treat all infected trees in 1 year. If all infection centers could be located and effectively treated, spread of the disease would stop. However, post-treatment examinations would be required annually for several years, because root grafts in oaks can persist for 1 to 6 years (Himelick and Fox 1961).

Oak wilt may not spread locally for several years but may then resume after successful transmission through a root graft. Tree mortality from oak wilt would end after several years, and infection centers would be eliminated or contained. Most openings would remain at or near current size. Mast production would stabilize and eventually start to increase. The timber volume loss would be insignificant, and many dead or dying trees could be salvaged.

Alternative 3.

This alternative is a multi-year oak wilt control program, treating infection centers in a predetermined order.

Post-treatment examinations, as outlined in Alternative 2, would also be required with this treatment. Tree mortality from oak wilt would increase annually in untreated areas. Spread of the disease would continue and accelerate in untreated infection centers. Openings resulting from tree mortality would increase in untreated stands and remain at or near current size in most cases. Some openings would increase in size until control measures were applied. Mast production would decline until all areas were treated and then it would stabilize.

Timber volume loss would be minimal, and some dead trees could be salvaged, depending on local market conditions and the amount of area treated annually. Some long-distance spread could occur during the treatment period. Such spread would necessitate continual monitoring for new oak wilt infection centers.

Factors affecting the cost and effectiveness of control options include location of infection center, tree density, personnel involved, and size of infection center. Table 2 provides general information on cost and effectiveness of oak wilt control options in three treatment categories. Cost and effectiveness categories are based on the authors' interpretation of the cited literature. The terminology used to rank categories (i.e. low, medium, high) was provided for general comparison of treatments. Cited literature provides more definite information for some control procedures.

RECOMMENDATIONS

To protect and maintain the red oak resource on Necedah Wildlife Refuge, an oak wilt control program should be initiated. The large number of infected trees and the diversity of their distribution preclude a large-scale eradication program. Thus, Alternative 3, using a vibratory plow and deep-girdle, is recommended for implementation on the Refuge. This alternative would provide for orderly control, reduce impact on Refuge environment, reduce the economic impact, be sound pathologically, and provide an opportunity to refine control techniques annually.

Should a decision to control oak wilt be made, personnel from the Forest Insect and Disease Management Staff Unit will provide assistance in all phases of treatment.

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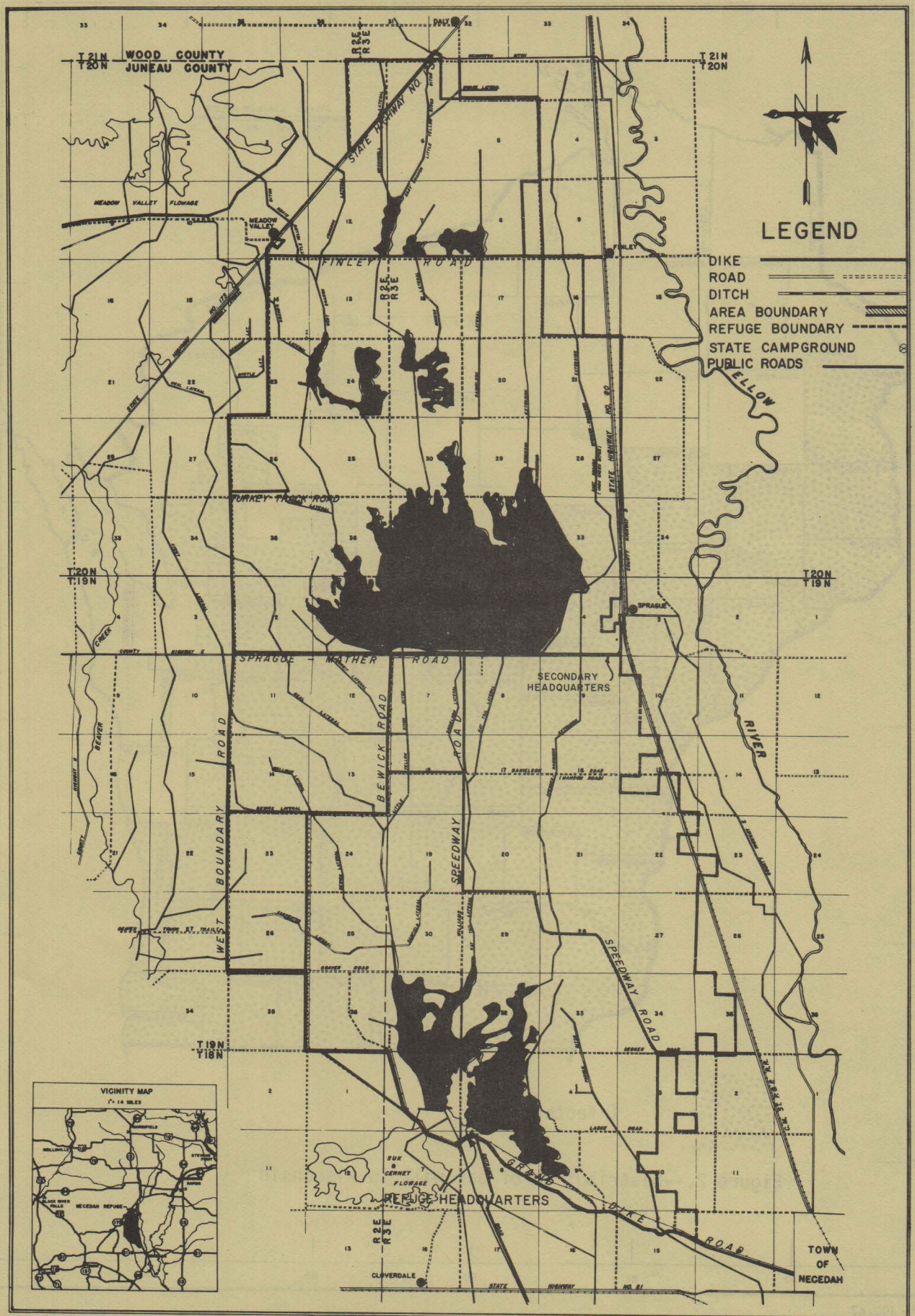

Figure 1.--Necedah National Wildlife Refuge, Wisconsin

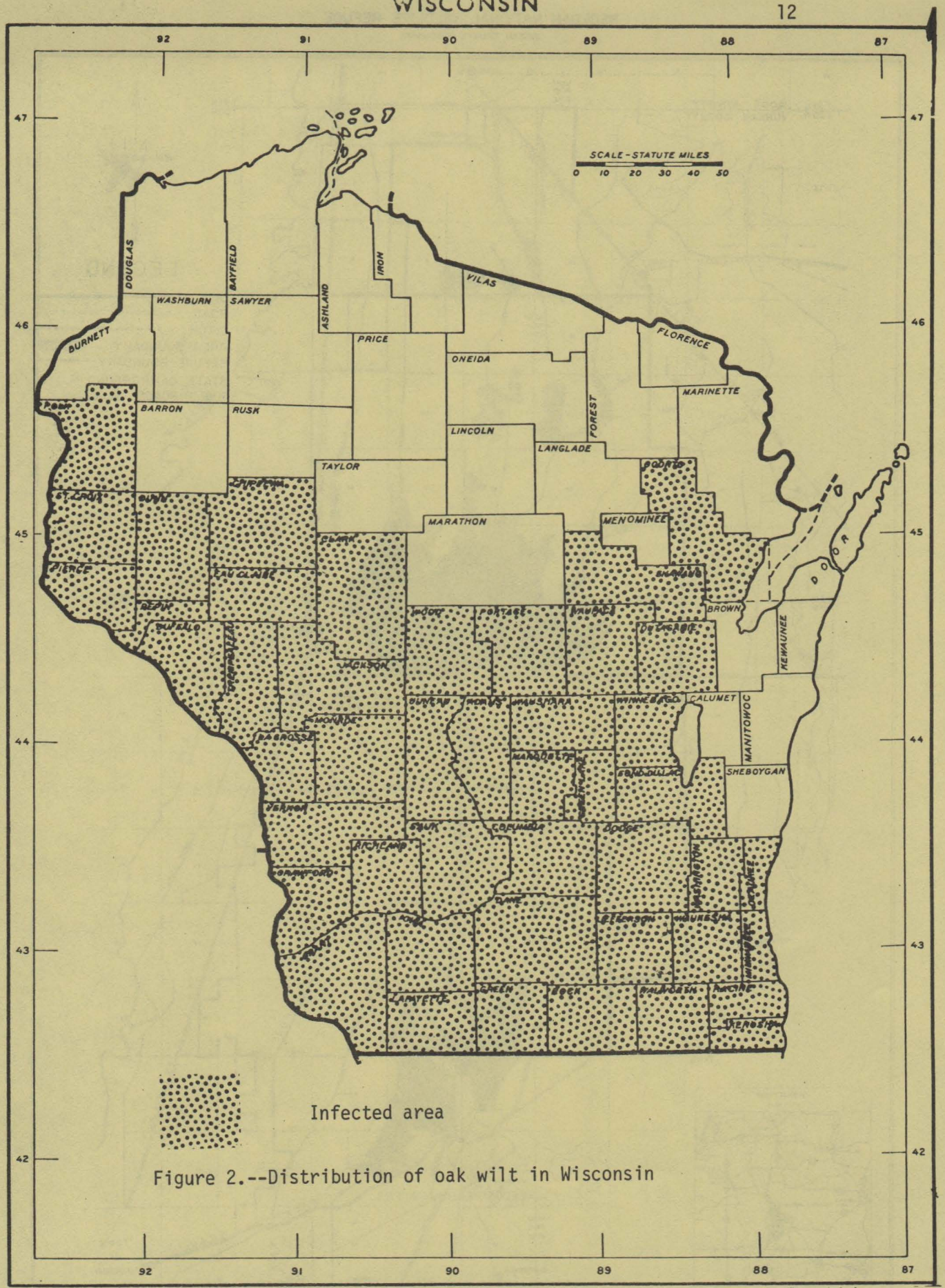

Figure 2.--Distribution of oak wilt in Wisconsin

Table 1.--Numbers and volumes of red oak trees infected with oak wilt on the Necedah National Wildlife Refuge, 1978, estimated from photo interpretation.

Category	Photo interpretation results		Photo interpretation results with ground-check correction[b/]	
	Trees	Volume	Trees	Volume
	Number	Cords[a/]	Number	Cords
Clustered dead or wilted oak trees (98 clusters)	2,444	437	1,833	328
Single dead or wilted oak trees	160	29	46	8
Total dead or wilted oak trees	2,604	466	1,879	336

[a/] cords/tree = 0.179

[b/] correction factor = 0.75 for clustered and 0.29 for single trees

Table 2.--Cost and effectiveness of oak wilt control procedures

Treatment category	Control procedure	Cost category	Effectiveness category
Sanitation	Deep girdle to heartwood; remove bark to root collar; leave trees standing	Moderate	Moderate, 79% effective in southern W. Virginia; less effective in northern W. Virginia (True and Gillespie 1961)
Sanitation	Deep girdle to heartwood; leave trees standing until dry; cut trees	Low	Low (Ohman et al. 1959)
Sanitation	Cut wilted trees at first symptom appearance	Moderate	Low (Kuntz and Riker 1956)
Sanitation	Poison wilted trees with cacodylic acid at first symptom appearance	Low	Moderate, 40 to 50% reduction in infected trees and infection centers (Rexrode 1977)
Sanitation	Cut and burn diseased trees	Moderate	Low (Jones and Bretz 1958)
Isolation and sanitation	Girdle and poison diseased trees and all healthy oaks within 50' of infection center	Moderate	Moderate (Ohman et al. 1959)
Isolation	Leave diseased trees standing; poison all oaks within 50' of infection center	Low	Low (Jones and Bretz 1958)
Isolation and sanitation	Cut diseased trees; cut healthy trees within 50' of infection center; poison all stumps	High	High, 90% or more effective in Pennsylvania; sacrifice healthy oaks (Jones and Phelps 1972)
Isolation and sanitation	Cut and burn diseased trees; poison all oaks within 50' of infection center	High	Low (Jones and Bretz 1958)

Table 2.--continued

Treatment category	Control procedure	Cost category	Effectiveness category
Isolation and sanitation	Use conventional trencher to sever roots around infected trees; includes secondary barrier; trench to 40"; deep-girdle infected trees	High	High, trench must be backfilled; time-consuming; not effective in rocky soil; must girdle in early disease stages (French and Stienstra 1975)
Isolation and sanitation	Use vibratory plow to sever roots; include secondary barrier; trench to 60"; deep-girdle infected trees	Moderate-high	High, very fast; effective in all but very rocky soils; must girdle in early disease stages (Mizicko and Stienstra 1977)
Isolation and sanitation	Use Vapam[a/] or methyl bromide to kill roots in barrier zone; include secondary barrier; deep girdle infected trees	High	Moderate-high: adverse effects on ground vegetation; time-consuming; effective on rocky, but not waterlogged soils

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